NATIONAL AERONAUTICS AND SPACE

ADMINISTRATION

NsG-67

SURFACE IONIZATION PHENOMENA

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

STATUS REPORT

TO

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TITLE OF RESEARCH

SURFACE IONIZATION PHENOMENA

NsG-67

Submitted By

E. E. Muschlitz, Jr.
C. S. Harden

Department of Chemistry
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

August, 1965

1. Period Covered: March 1, 1965 - August 31, 1965

2. Resume of Research Progress

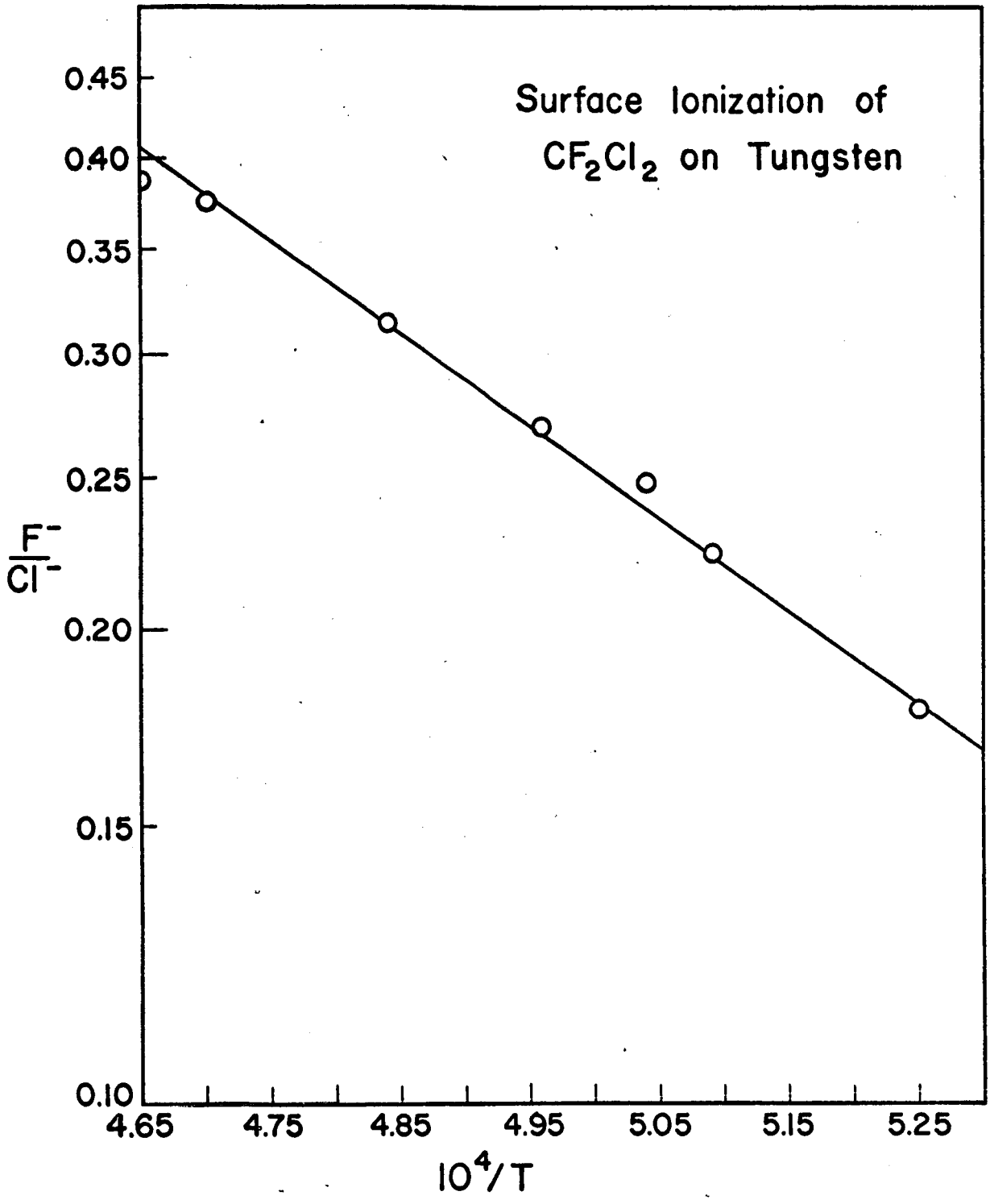
Preliminary experiments with the surface ionization apparatus have been extended to additional halocarbons. In every case so far investigated the molecules are completely dissociated on a tungsten surface in the temperature range invesitgated (1900 - 2200° K). The preliminary results for CF_2Cl_2 are shown in the following figure.

These results are quite encouraging and we plan to attempt the measurement of electron affinities by the difference method. Consider a beam of molecules containing two different electronegative atoms, X and Y; e.g., $C\ X_m\ Y_n$, incident on a hot surface. If dissociation is complete and equilibrium is attained, statistical mechanical arguments [T. L. Bailey, J. Chem. Phys. - 28, 792 (1958)] show that:

$$\ell n\ (i_{X^-}\ /\ i_{Y^-}) = [E(X) - E(Y)]\ /\ RT + \ell n\ [(m/n)\ (Q_Y/Q_X)\ (Q_{X^-}/Q_{Y^-})]$$

where i_{X^-} and i_{Y^-} are the measured negative ion currents, E(X) - E(Y) the difference in the electron affinities, and Q_k the partition function for species k. For halogen atoms, a small temperature dependence exists in the ratio Q_Y/Q_X (because of the low lying $^2P_{1/2}$ states) which must be taken into account. The method has the distinct advantage that it is independent of the work function of the surface.

Our attempts to observe O^- from the surface ionization of O_2 have so far failed because of background ions produced by electron impact in the gas phase. To eliminate this problem, an eletromagnetically driven beam chopping device has been constructed. The chopper simultaneously intercepts the molecular beam and also a light beam in order


Surface Ionization of
CF_2Cl_2 on Tungsten
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
$\frac{F^-}{Cl^-}$
4.65
4.75
4.85
4.95
5.05
5.15
5.25
$10^4/T$

to provide a reference signal. The chopped light beam is detected by a Texas Instruments type LS-400 silicon light sensor. The chopper is driven at its resonance frequency of 80cps by a Hewlett Packard Model 200 AB audio oscillator through a suitable matching transformer. A Princeton Applied Research Model JB-4 phase sensitive amplifier is used to detect the ion current after mass analysis. This system should not only eliminate ions formed in the residual gas but also ions originating from impurities in the filament.

The phase sensitive detecting system has not yet operated satisfactorily. The main problem with it arises from the difficulty in aligning the chopper with the molecular beam. Evidently the rest position of the chopper does not correspond to the mid-point of its motion when it is in operation. Provision will have to be made for moving the chopper mechanism while it is in operation and the system under vacuum.

3. Future Direction of Research

It is planned to attempt measurements of the electron affinities of O, CN, NO, and NO_2 using the difference method. Suitable compounds that might be used are: OF_2, CH_2ClCN, NOCl, and CCl_3NO_2, since the electron affinities of the halogens are now well known.

A Bendix magnetic electron multiplier has recently been obtained. Its incorporation in the apparatus will provide the additional sensitivity needed to extend the measurements to lower temperatures and to other systems, particularly O_2, N_2O, and NO.

No work has yet been done on positive surface ionization. However, design of a suitable oven for the production of beams of alkali atoms and alkali halide molicules is now under construction.

4. Publications and Technical Papers

1) "The Mass Spectrometer as a Research Instrument," E. E. Muschlitz, Jr. Invited paper presented at the American Chemical Society Symposium on "Recent Advances in Physical Chemistry," New York, September, 1960. To be published in J. Chem. Ed.

2) "Mass Spectra of Positive and Negative Ions in Nitrous and Nitric Oxides," Thesis by C. S. Harden. Submitted as a NASA Technical Report.

5. Period of Grant: July 1, 1963 - June 30, 1966

6. Personnel

(1)	E. E. Muschlitz, Jr.	Professor of Chemistry Principal Investigator
(2)	C. S. Harden	Graduate Assistant (NASA supported)